A COST COMPARISON OF FOUR CONTAINER SYSTEMS TO EXPORT DRY EDIBLE BEANS TO THE UNITED KINGDOM

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PREFACE

This report describes research to find less costly and more efficient methods of handling and transporting dry edible beans by comparing the estimated costs for four alternative systems for shipping dry edible beans from Michigan to the United Kingdom.

The research was conducted in Saginaw, Mich., and in various cities in the United Kingdom. It is part of a broader program of ARS research to develop systems that will reduce the costs of distributing agricultural products.

Numerous shippers and receivers of dry edible beans from Michigan supplied the facilities and equipment to make this study possible; they are:

Foreign Agricultural Service, USDA
Furnes, Withy, and Company
Michigan Bean Commission
Michigan Bean Shippers Association
Michigan Department of Agriculture
Michigan State University
United Kingdom Research Committee

Russell H. Hinds, Jr., industry economist, Transportation and Packaging Research Laboratory, Agricultural Marketing Research Institute; Robert C. Mongelli, agricultural economist, Market Operations Research Laboratory, Agricultural Marketing Research Institute; and William F. Goddard, Jr., mechanical engineer, Southern Region, Orlando, Fla., all with Agricultural Research Service, assisted in gathering data. Appreciation is expressed to them and to all contributors who have made this study possible.

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By Joseph P. Anthony, Jr.[1/]

SUMMARY

Estimated costs for four containerized export systems for shipping dry edible beans from the United States to the United Kingdom were studied. The four systems included beans transported in the following media: burlap bags, paper bags, polypropylene bags, and bulk-loaded into 20-foot van containers.

The paper bag system had the highest estimated total cost at $942.37 per van container. This amount was $74.13 more per van container than the least expensive system, the bulk-loaded. The burlap bag system's estimated total cost was $926.32 per van container or $58.08 more per van container than the cost of the bulk-loaded system. The polypropylene bag system had an estimated total cost of $914.32 per van container. This amount was $46.08 more per van container than the cost of the bulk system. The bulk-loaded system, which was the least expensive overall, costs an estimated $868.24 per van container to move 40,000 pounds of dry edible beans from Michigan to the United Kingdom.

With transport charges on a per-container basis, the main advantage with the bulk-loaded system was savings from the expense of purchasing container bags as needed by the other systems. The remainder of the savings was generated by reducing costs for handling and damage.

INTRODUCTION

In the U.S. balance of international payments, the exporting of agricultural commodities is of major importance. The importance of this balance has been illustrated by the recent difficulties that the United States has experienced in reversing an unfavorable flow of payments.

This report will consider containerized shipments that originate in the United States, specifically in Michigan, and that terminate in the United Kingdom. The United States is the fifth leading dry edible bean producer in the world and accounts for over 5.5 percent of the world's production. The United States is the leading exporter of dry edible beans in the world and can boast over 40 percent of the total international bean exports.

Michigan is the leading bean-growing State and produces about 35 percent of the U.S. total. This State alone accounts for almost 2 percent of the total dry edible bean production in the world. The Michigan dry edible bean industry

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is the principal supplier of the British market, with Canada a close second. The value of the 1971-72 Michigan exports to the United Kingdom was approximately $11 million.

The United Kingdom, on the other hand, produces no dry edible beans for human consumption. The United Kingdom, long the world's leading importer of dry edible beans but recently slipping behind Japan in this category, is the United States' leading customer and takes over 30 percent of these bean exports.

Containerization used for bean shipments is a relatively recent development. Prior to 1970, very little bean export traffic left the United States in van containers. Now, because of changes in the rate structure and in services offered, virtually all export shipments from Michigan to the United Kingdom go in van containers.

Because of the density of beans, van containers (O.D. 20' x 8' x 8') are used for these shipments. The generally accepted (in respect to legal weight limitations) 40,000-pound payload can be easily placed in these shorter containers. Four hundred bags of beans or 40,000 pounds in bulk are loaded into each container.

Applying this factor of 400 bags or hundredweight per van container to the United States' 1971-72 exports of beans, about 9,000 containers would have been required to handle all U.S. bean exports. The traffic to the United Kingdom alone could have involved about 3,000 containers during 1971-72.

These shipments from Michigan to the United Kingdom accentuate the multimodal nature of containerized transport. The truck-rail-barge-ship-truck model integration also demonstrates the flexibility of containerization.

The basic pattern of handling and transporting export shipments of dry edible beans from Michigan bean elevators to United Kingdom processing plants underwent some basic changes during 1970. At that time, the shipping line that usually carried the bean shipments announced the discontinuance of their conventional break-bulk shipments and introduced an all-containerized service. The basic shipping pattern is structured around three operations:

1. Shipping at the originating elevator where the bags are filled with dry edible beans, closed, handled, and loaded into the van container, or where the beans are loaded in bulk directly into the van container. With the exception of bulk loading, this operation is similar to the break-bulk method previously employed.

2. Transporting the loaded van containers from the originating bean elevator to the receiver's processing plant.

3. Receiving and unloading beans in either bags or bulk at the U.K. processing plant.

The conventional method of shipping the beans in burlap bags in van containers (model 1) was used as a base or standard for comparison with the alternative transporting and handling systems. These alternative systems included beans packed in multiwall paper bags in van containers (model 2), beans packed in woven polypropylene bags in van containers (model 3), and beans bulk-loaded into van containers (model 4).

The costs of performing each function or group of functions in the four systems are represented symbolically, with the cost of each method being the total of its components. Six sets of comparisons are possible among these four transporting and handling systems:

Burlap Bag System (Model 1) - Paper Bag System (Model 2)
Burlap Bag System (Model 1) - Polypropylene Bag System (Model 3)
Burlap Bag System (Model 1) - Bulk-Loaded System (Model 4)
Paper Bag System (Model 2) - Polypropylene Bag System (Model 3)
Paper Bag System (Model 2) - Bulk-Loaded System (Model 4)
Polypropylene Bag System (Model 3) - Bulk-Loaded System (Model 4)

The objective of these distribution systems is to provide dry edible beans of acceptable quality at the processing plant in the United Kingdom. These systems are not unique in themselves but share similar costs and techniques.

ASSUMPTIONS UNDERLYING THE RESEARCH

Originating elevator assumptions.--The elevator shipping operation for all four models was assumed to begin the moment that the beans were removed from storage in preparation for shipment. These operations were assumed to have labor and equipment requirements and costs that were the same for all models using 100-pound bags (models 1, 2, and 3). Actual time studies showed no appreciable difference among any of the bag-loading methods. The Area Wage Survey (Bureau of Labor Statistics) was the source for all U.S. wage rates quoted. Figures 1 and 2 show burlap bags during and after loading.

Figure 1.--Burlap bags being loaded in the van container.

Figure 2.--Burlap bags immediately after loading.

Transportation assumptions.--Actual transportation costs paid by the shipper and receiver for the containerized export shipment were used for this study.

Processing plant assumptions.--The processing plant receiving operation for all four models was assumed to end the moment that the last bag or bean was removed from the van container and placed in storage. The burlap bags and the woven polypropylene bags were assumed to have some resale value and were resold.

PROCEDURE

Because of the similarity of functions, factors that affected transporting and handling costs did not vary significantly among the alternative systems. Table 1 identifies the cost factors of each distribution system associated with the major functions: Elevator shipping operations, transportation, and processing plant receiving operations. The variables shown in the models in Exhibit A are expressed in symbolic form, so that the functional relationship between cost factors and these functions could be examined (app. 1). The components of each model show specific variables applicable to an estimation of costs for the functions.

The costs of bagging, loading, and unloading were measured by direct observation. The transportation costs were obtained from the carriers. Material costs were obtained from the manufacturers.

The three handling methods that employed bags were alike in all respects except for the bags themselves. All bags were filled, closed, and loaded following basically the same procedures. All van containers were loaded and unloaded by hand (fig. 3).

Contrasted to these methods was the bulk system, where the beans were loaded mechanically in bulk through a roof hatch into a van container exactly like

TABLE 1.--Cost factors allocated to specific operations and systems

Operation	System	Cost factor
Elevator-shipping	Burlap bag Paper bag Polypropylene bag	Bags Filling, sewing, and moving bags (labor and materials) Inplant handling Loading van container (labor and equipment)
	Bulk-loaded	Loading van container (labor, equipment, and materials)
Transportation	Burlap bag Paper bag Polypropylene bag Bulk-loaded	Truck costs in United States Barge costs Rail and ocean freight costs Truck costs in United Kingdom
Plant-receiving	Burlap bag	Unloading van containers (labor and equipment) Reselling burlap bags
	Paper bag	Unloading van containers (labor and equipment) Damaged bags and lost payload Disposing of empty bags
	Polypropylene bag	Unloading van containers (labor and equipment) Reselling polypropylene bags
	Bulk-loaded	Unloading van containers (labor and equipment)

Figure 3.--Bagged beans being unloaded.

those used for bagged loads. At destination, these containers were unloaded mechanically (fig. 4).

Figure 4.--Bulk-loaded van container being unloaded by power-lift chassis.

All transportation costs are the same for each method, because costs are quoted on a per-container basis. This rate applies no matter what the cargo is, as long as it is one container load.

The source of basic data and the procedure used to generate data for particular model components are shown in appendix 2. To estimate cost components, primary data were developed for as many components as possible, while secondary data were used to complete the models.

RESULTS

Data have been presented in tables 2 through 5 so that other investigators may evaluate and compare the data components used to derive the final results for this study with data available to them.2/

2/ By substituting different data, other investigators could generate cost estimates more appropriate to their use. Data tend to change over time because of changes in technology and economic conditions. Thus, more recent data would likely provide different cost estimates.

TABLE 2.--Model 1: Burlap bag containerized export system

$$Y_1 = aN + b + c + d + e + f + g + h + i - jN$$

Cost factor	Symbol	Estimated costs: Per container 1/	Estimated costs: Per bag
		Dollars	Dollars
Bags	aN	116.00	0.2900
Bag filling and closing	b	11.79	.0294
Handling 2/	c	7.36	.0184
Loading 2/	d	12.98	.0325
Trucking (U.S.)	e	100.00	.2500
Barge	f	50.00	.1250
Rail and ocean freight	g	510.00	1.2750
Trucking (U.K.)	h	168.00	.4200
Unloading 3/	i	10.19	.0255
Subtotal	$Y_1 + jN$	986.32	2.4658
Less:			
Resale value of bags	jN	60.00	.1500
Total	Y_1	926.32	2.3158

1/ A full container load consisted of N = 400 bags.
2/ Hourly labor costs in the United States, based on Area Wage Survey, Bureau of Labor Statistics, were $3.30 for laborers and $3.80 for supervisors.
3/ Hourly labor costs in the United Kingdom, based on reported wage rates, were $1.38 for laborers, $1.48 for forklift operators, and $1.85 for supervisors.

The final results were derived by applying the data components to each of the models. Applications of the data components to the models are shown in appendix 3. The results generated by the derived data components are presented for each distribution system by cost factors (tables 2 through 5). The paper bag system was estimated to have the highest cost at $942.37 (table 3) per van container. The conventional burlap bag system was estimated to cost $926.32 (table 2), which is the third largest estimated cost among the four systems. The polypropylene bag system, which had the lowest cost of the three bag systems, was estimated to cost $914.32 (table 4) per van container. The bulk-loaded system was estimated to cost $868.24 (table 5), the least expensive model of the entire comparison. It should be realized that, considering the extremely limited destination facilities for handling and storing dry edible beans in bulk, the bulk-loaded containerized export system is placed at an operational disadvantage that is not reflected in the estimated costs. Facilities and equipment must be diverted from their primary functions to accommodate bulk loads so that a cost distortion results.

TABLE 3.--Model 2: Paper bag containerized export system

$$Y_2 = a'N + b + c + d + e + f + g + h + i + k + d''$$

Cost factor	Symbol	Estimated costs	
		Per container 1/	Per bag
		Dollars	Dollars
Bags	a'N	60.00	0.1500
Bag filling and closing	b	11.79	.0294
Handling 2/	c	7.36	.0184
Loading 2/	d	12.98	.0325
Trucking (U.S.)	e	100.00	.2500
Barge	f	50.00	.1250
Rail and ocean freight	g	510.00	1.2750
Trucking (U.K.)	h	168.00	.4200
Unloading 3/	i	10.19	.0255
Loss from damaged bags 4/	k	5/ 10.00	.0250
Disposing of empty bags 6/	d"	2.05	.0052
Total	Y_2	942.37	2.3560

1/ A full container load consisted of N = 400 bags.

2/ Hourly labor costs in the United States, based on Area Wage Survey, Bureau of Labor Statistics, were $3.30 for laborers and $3.80 for supervisors.

3/ Hourly labor costs in the United Kingdom, based on reported wage rates, were $1.38 for laborers, $1.48 for forklift operators, and $1.85 for supervisors.

4/ Estimated loss of approximately one full bag per van container from observation reports.

5/ Approximated value.

6/ Estimated.

With transportation charges on a per-van-container basis, the main savings from using the bulk-loaded system arose from avoiding the cost of the bags used in the other system .

A summary of the various handling costs for the bag and bulk systems is presented in table 6. The bulk system reduced handling costs per van container from $42.32 to $40.24, a savings of $2.08. The remainder of the savings from using the bulk system was generated by reduced costs for damages and bags.

TABLE 4.--Model 3: Polypropylene bag containerized export system

$$Y_3 = a''N + b + c + d + e + f + g + h + i - j'N$$

Cost factor	Symbol	Estimated costs	
		Per container 1/	Per bag
		Dollars	Dollars
Bags	$a''N$	104.00	0.2600
Bag filling and closing	b	11.79	.0294
Handling 2/	c	7.36	.0184
Loading 2/	d	12.98	.0325
Trucking (U.S.)	e	100.00	.2500
Barge	f	50.00	.1250
Rail and ocean freight	g	510.00	1.2750
Trucking (U.K.)	h	168.00	.4200
Unloading 3/	i	10.19	.0255
Subtotal	$Y_3 + j'N$	974.32	2.4358
Less: Resale value of bags	$j'N$	60.00	.1500
Total	Y_3	914.32	2.2858

1/ Full container N = 400 bags.
2/ Hourly labor costs in the United States, based on Area Wage Survey, Bureau of Labor Statistics, were \$3.30 for laborers and \$3.80 for supervisors.
3/ Hourly labor costs in the United Kingdom, based on reported wage rates, were \$1.38 for laborers, \$1.48 for forklift operators, and \$1.85 for supervisors.

TABLE 5.--Model 4: Bulk-loaded containerized export system

$$Y_4 = d' + e + f + g + h + i'$$

Cost factor	Symbol	Estimated costs	
		Per container 1/	Per cwt
		Dollars	Dollars
Loading 2/	d'	30.29	0.0757
Trucking (U.S.)	e	100.00	.2500
Barge	f	50.00	.1250
Rail and ocean freight	g	510.00	1.2750
Trucking (U.K.)	h	168.00	.4200
Unloading 3/	i'	9.95	.0249
Total	Y_4	868.24	2.1706

1/ A full container load was 40,000 pounds.
2/ Hourly labor costs in the United States, based on Area Wage Survey, Bureau of Labor Statistics, were \$3.30 for laborers and \$3.80 for supervisors.
3/ Hourly labor costs in the United Kingdom, based on reported wage rates, were \$1.38 for laborers, \$1.48 for forklift operators, and \$1.85 for supervisors.

TABLE 6.--Summary of handling costs for bags and for bulk-loading and unloading dry edible beans shipped in van containers

Cost element	Handling costs			
	Labor	Materials	Equipment	Total
	Dollars	Dollars	Dollars	Dollars
Bags				
Filling and closing	10.56	1.04	0.19	11.79
Inplant handling	7.34	--	.02	7.36
Loading	10.24	2.00	.74	12.98
Unloading	9.39	--	.80	10.19
Total	37.53	3.04	1.75	42.32
Bulk				
Loading	9.68	20.50	.11	30.29
Unloading	6.92	1.92	1.11	9.95
Total	16.60	22.42	1.22	40.24

APPENDIX 1.--MODELS OF CONTAINERIZED EXPORT SYSTEMS

Model 1.--Burlap Bag Containerized Export System

Y_1 = Total transfer costs of burlap bag method for one van container for one shipment.

$Y_1 = aN + b + c + d + e + f + g + h + i - jN$, where:

a = Cost of each burlap bag.

N = Number of bags in each full van container.

b = Costs for labor and materials to fill and close N bags.

  b = lm + n + op, where:

    l = man-hours per van container to fill and close N bags.

    m = wage rate for laborers (AWS).

    n = costs of closing materials.

    o = equipment-hours per van container to close N bags.

    p = ownership and operating costs per hour of operation for closing equipment.

c = Inplant handling costs, including labor and equipment, to move N bags to van container.

  c = qm + rs, where:

    q = man-hours per van container for inplant handling (related to loading) of N bags.

    m = wage rate for laborers (AWS).

    r = equipment-hours per van container for inplant handling (related to loading) of N bags.

    s = ownership and operating costs per hour of operation for handling equipment.

d = Labor and equipment costs to load a van container with N bags.

  d = b'm + c' + tm + uv + wx, where:

    b' = man-hours to prepare van for loading.

m = wage rate for laborers (AWS).
c' = materials cost for loading.
t = man-hours per van container to load N bags.
u = equipment-hours per van container to load N bags.
v = ownership and operating costs per hours of operation for loading equipment.
w = man-hours of supervision per van container.
x = wage rate for supervisor (AWS).

e = Truck transportation charge in the United States per van container.
f = Barge transportation charge in the United States per van container.
g = Ocean freight charge, includes rail trip to port and related handling.
h = Truck transportation charge in the United Kingdom per van container.
i = Labor and equipment costs to unload a van container with N bags.

$i = yz + l'm' + n'o' + p'q'$, where:

y = man-hours per van container to unload N bags (laborers).
z = wage rate of laborers.
l' = man-hours per van container to unload N bags (fork truck operator).
m' = wage rate for fork truck operator.
n' = equipment-hours per van container to unload N bags.
o' = ownership and operating costs for equipment to unload N bags.
p' = man-hours of supervision per van container.
q' = wage rate for supervisors.

j = Resale value of each burlap bag.

Model 2.--Paper Bag Containerized Export System

Y_2 = Total transfer costs of paper bag method for one van container for one shipment.

$Y_2 = a'N + b + c + d + e + f + g + h + i + k + d''$, where:

a' = Cost of each paper bag.
N = Number of bags in each full van container.
b = Costs for labor and materials to fill and close N bags.

$b = lm + n + op$, where:

l = man-hours per van container to fill and close N bags.
m = wage rate for laborers (AWS).
n = costs of closing materials.
o = equipment-hours per van container to close N bags.
p = ownership and operating costs per hour of operation for closing equipment.

c = Inplant handling costs, including labor and equipment, to move N bags to van containers.

$c = qm + rs$, where:

q = man-hours per van container for inplant handling.
m = wage rate for laborers (AWS).
r = equipment-hours per van container for inplant handling (related to loading) of N bags.
s = ownership and operating costs per hour of operation for handling equipment.

d = Labor and equipment costs to load a van container with N bags.

$d = b'm + c' + tm + uv + wx$, where:

b' = man-hours to prepare van for loading.
m = wage rate for laborers (AWS).

c' = materials cost for loading.
t = man-hours per van container to load N bags.
u = equipment-hours per van container to load N bags.
v = ownership and operating costs per hour of operation for loading equipment.
w = man-hours of supervision per van container.
x = wage rate for supervisor (AWS).

e = Truck transportation charge in the United States per van container.
f = Barge transportation charge in the United States per van container.
g = Ocean freight charge, includes rail trip to port and related handling.
h = Truck transportation charge in the United Kingdom per van container.
i = Labor and equipment costs to unload a van container with N bags.

$i = yz + l'm' + n'o' + p'q'$, where:

y = man-hours per van container to unload N bags (laborers).
z = wage rate for laborers.
l' = man-hours per van container to unload N bags (fork truck operator).
m' = wage rate for fork truck operator.
n' = equipment-hours per van container to unload N bags.
o' = ownership and operating costs for equipment to unload N bags.
p' = man-hours of supervision per van container.
q' = wage rate for supervisors.

k = Cost of product lost as a result of damaged paper bags.
d'' = Cost of disposing of empty paper bags.

$d'' = h'z + i''$, where:

h' = man-hours to dispose of empty paper bags.
z = wage rate for laborers (United Kingdom).
i'' = rubbish disposal cost (for bags).

Model 3.--Polypropylene Bag Containerized Export System

Y_3 = Total transfer costs of polypropylene bag method for one van container for one shipment.

$Y_3 = a''N + b + c + d + e + f + g + h + i - j'N$, where:

a'' = Cost of each polypropylene bag.
N = Number of bags in each full van container.
b = Costs for labor and materials to fill and close N bags.

$b = lm + n + op$, where:

l = man-hours per van container to fill and close N bags.
m = wage rate for laborers (AWS).
n = costs of closing materials.
o = equipment-hours per van container to close N bags.
p = ownership and operating costs per hour of operation for closing equipment.

c = Inplant handling costs, including labor and equipment, to move N bags to van containers.

$c = qm + rs$, where:

q = man-hours per van container for inplant handling (related to loading) of N bags.
m = wage rate for laborers (AWS).
r = equipment-hours per van container for inplant handling (related to loading) of N bags.

s = ownership and operating costs per hour of operation for handling equipment.

d = Labor and equipment costs to load a van container with N bags.

$d = b'm + c' + tm + uv + wx$, where:

b' = man-hours to prepare van for loading.

m = wage rate for laborers (AWS).

c' = materials cost for loading.

t = man-hours per van to load N bags.

u = equipment-hours per van container to load N bags.

v = ownership and operating costs per hour of operation for loading equipment.

w = man-hours of supervision per van container.

x = wage rate for supervisor (AWS).

e = Truck transportation charge in the United States per van container.

f = Barge transportation charge in the United States per van container.

g = Ocean freight charge, includes rail trip to port and related handling.

h = Truck transportation charge in the United Kingdom per van container.

i = Labor and equipment costs to unload a van container with N bags.

$i = yz + l'm' + n'o' + p'q'$, where:

y = man-hours per van container to unload N bags (laborers).

z = wage rate for laborers.

l' = man-hours per van container to unload N bags (fork truck operator).

m' = wage rate for fork truck operator.

n' = equipment-hours per van container to unload N bags.

o' = ownership and operating costs for equipment to unload N bags.

p' = man-hours of supervision per van container.

q' = wage rate for supervisors.

j' = Resale value of each polypropylene bag.

Model 4.--Bulk-Loaded Containerized Export System

Y_4 = Total transfer costs of bulk method for one van container for one shipment.

$Y_4 = d' + e + f + g + h + i'$, where:

d' = Labor and equipment costs to load one van container with 100 N pounds in bulk, where N = number of bags in models 1, 2, and 3.

$d' = e'm + f' + r'm + s't' + u'x$, where:

e' = man-hours to set up polyethylene liner.

m = wage rate for laborers (AWS).

f' = materials costs for bulk loading.

r' = man-hours per van container to load 100 N pounds in bulk.

s' = equipment-hours per van container to load 100 N pounds in bulk.

t' = ownership and operating costs per hour of operation for equipment.

u' = man-hours of supervision per van container.

x = wage rate for supervisors (AWS).

e = Truck transportation charge in the United States per van container.

f = Barge transportation charge in the United States per van container.

g = Ocean freight charge, includes rail trip to port and related handling.

h = Truck transportation charge in the United Kingdom per van container.

i' = Labor and equipment costs to unload one van container with 100 N pounds in bulk.

$i' = v'z + w'x' + y'q' + z'm' + g'z + d'''$, where:

v' = man-hours per van container to unload 100 N pounds in bulk (laborers).

z = wage rate for laborers (United Kingdom).

w' = equipment-hours per van container to unload 100 N pounds in bulk.

x' = ownership and operating costs per hour of operation for equipment.

y' = man-hours of supervision per van container.

q' = wage rate for supervisors (United Kingdom).

z' = man-hours per van container to unload 100 N pounds in bulk (forklift operator).

m' = wage rate for forklift operator.

g' = man-hours to take down polyethylene liner.

d''' = cost of disposing of polyethylene liner.

$d''' = h''z + i''$, where:

h'' = man-hours to dispose of polyethylene liner.

z = wage rate for laborers (United Kingdom).

i'' = rubbish disposal cost (for liner).

APPENDIX 2.--SOURCE OF BASIC DATA AND DERIVATION OF SPECIFIC DATA

A.--Derivation of bag costs.

Individual bag costs:[1]

10-oz burlap bag------------$0.29.
Multiwall paper bag--------- .15.
Polypropylene bag----------- .26.

With N = 400 bags per van container, the bag costs are:

$116 for burlap bags (aN).
60 for paper bags (a'N).
104 for polypropylene bags (a''N).

B.--Derivation of wage rates.

U.S. wage rates.[2]

Laborers-------------------$3.30 per hour.
Supervisor----------------- 3.80 per hour.

U.K. wage rates.[3]

Laborers-------------------$72 for a 52-hour workweek or $1.38 per hour.
Forklift operator---------- 77 for a 52-hour workweek or $1.48 per hour.
Supervisor----------------- 96 for a 52-hour workweek or $1.85 per hour.

C.--Derivation of filling and closing costs.

Filling and sewing costs estimates were derived by using the filling rate (5 bags per minute) of the equipment plus an allowance for delays and fatigue.

Man-hours to fill and close N bags = 3.200, where N = 400.

3.200 ($3.30)[1] = $10.56 labor cost to fill and close.

See footnotes at end of tabulation.

$10.56 = labor cost.
1.04 = material cost - thread at $4.15 per cone to close 1,600 bags per cone.
.19 = equipment cost = 1.600 equipment-hours at $0.12 per hour.2/
11.79 = filling and closing costs.

D.--Derivation of inplant handling (related to loading) costs.
These estimates of costs were derived from basic data gathered in the bean elevators and include allowances for delays and fatigue.
Man-hours for loading - related inplant handling of N bags = 2.224.
2.224 ($3.30)4/ = $7.34 labor cost for inplant handling.
$7.34 = labor cost.
.02 = equipment cost = 2.224 equipment-hours at $0.01 per hour.5/
7.36 = inplant handling costs.

E.--Derivation of loading costs (d).
Loading-cost estimates were derived from basic data gathered in the bean elevators and include allowances for delays and fatigue.
Man-hours for preparing for loading = 0.500.
Man-hours for loading N bags = 2.221.
Man-hours for supervising loading = 0.333.
0.500 ($3.30)4/ = $1.65 labor cost for preparation.
2.221 ($3.30)4/ = 7.33 labor cost for loading.
0.333 ($3.80)4/ = 1.26 labor cost for supervision.
10.24 labor costs.
$10.24 = labor costs.
2.00 = materials cost for loading.1/
0.74 = equipment cost = 1.112 equipment-hours at $0.67 per hour.5/
12.98 = costs of loading.

F.--Derivation of unloading costs (i).
Unloading-cost estimates were derived from basic data gathered at the receivers' facilities in the United Kingdom and include allowances for delays and fatigue.
Man-hours for unloading N bags onto pallets = 4.856.
Man-hours for moving loaded pallets to storage = 0.807.
Man-hours for supervising unloading = 0.807.
4.856 ($1.38)4/ = $6.70 labor cost for unloading.
0.807 ($1.48)4/ = 1.20 labor cost for forklift.
0.807 ($1.85)4/ = 1.49 labor cost for supervision.
9.39 labor costs.
$9.39 = labor costs.
.80 = equipment cost = 0.807 equipment-hours at $0.99 per hour.5/
10.19 = costs of unloading.

G.--Derivation of bulk-loading costs (d').
Loading-cost estimates were derived from basic data gathered at the bean elevators and include allowances for delays and fatigue.
Man-hours for loading 100 N pounds in bulk = 1.897.
Man-hours for supervising loading = 0.317.

See footnotes at end of tabulation.

1.897 ($3.30)[4/] = $6.26 labor cost for loading.
0.317 ($3.80)[4/] = 1.20 labor cost for supervision.
7.46 labor costs.

$7.46 = labor costs.
.11 = equipment cost = 1.564 equipment-hours at $0.07 per hour.[5/]
7.57 = costs of bulk loading.

Materials costs for bulk loading.
$20.00 = one polyethylene liner.
.50 = kraft paper for top of load.
20.50 = materials costs (f').[1/]

H.--Derivation of bulk-unloading costs (i').

Unloading cost estimates were derived from basic data gathered at destination and include allowances for delays and fatigue.
Man-hours for unloading 100 N pounds in bulk = 2.917.
Man-hours for forklift operator = 0.583.
Man-hours for supervising unloading = 0.583.
2.917 ($1.38)[4/] = $4.02 labor cost for unloading.
0.583 ($1.48)[4/] = .86 labor cost for forklift.
0.583 ($1.85)[4/] = 1.08 labor cost for supervision.
5.96 labor costs.

$5.96 = labor costs.
1.11 = equipment cost = 0.583 equipment-hours at $1.90 per hour.[5/]
7.07 = costs of bulk unloading.

I.--Derivation of disposal costs for paper bags.

Disposal cost estimates were derived from basic data.
Man-hours for disposing of 400 paper bags = 0.755.
Rubbish disposal cost for paper bags (est.) = $1.00.
0.755 ($1.38)[4/] = $1.05 = labor costs for disposal.
1.00 = rubbish costs.
2.05 = costs of bag disposal.

J.--Derivation of disposal costs for polyethylene liner for bulk shipments.

Man-hours for disposing of polyethylene liner = 0.667.
Rubbish disposal cost for liner (est.) = $1.00.
0.667 ($1.38)[4/] = $0.92 = labor costs for disposal.
1.00 = rubbish costs.
1.92 = costs for liner disposal.

1/ Source: Michigan Bean Shippers Association.

2/ Source: Area Wage Survey, Bureau of Labor Statistics, Laborers-Materials Handling, Central Michigan. Wage rate does not include fringe benefits.

3/ Source: Observation report from USDA, ARS representative in Rotterdam, the Netherlands.

4/ See section B.

5/ See table 7.

TABLE 7.--Development of hourly ownership and operating costs for equipment inputs required for filling, sewing, and loading bags of dry edible beans into 20-foot van containers

Equipment and handling method	Replacement cost	Estimated life	Ownership costs: Annual depreciation 1/	Ownership costs: Insurance and taxes 2/	Ownership costs: Interest 3/	Ownership costs: Total	Operating costs: Power 4/	Operating costs: Repairs 5/	Operating costs: Total	Total annual costs	Estimated use per year	Estimated costs per hour of use 6/
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Hours	Dollars
Bag loading:												
Sewing machine	424.00	6	70.67	16.96	12.72	100.35	21.20	6.36	27.56	127.91	1,040	0.12
Hand truck	66.20	10	6.62	2.65	1.99	11.26	--	.99	.99	12.25	1,040	.01
Conveyor roller bed	1,539.00	8	192.37	61.56	46.17	300.10	23.08	23.08	46.16	346.26	520	.67
Bulk-loading:												
Spout	92.40	10	9.24	3.70	2.77	15.71	--	1.39	1.39	17.10	260	.07
Bagged unloading:												
Fork truck	9,097.00	8	1,137.13	363.88	272.91	1,773.92	7/ 136.46	136.46	272.92	2,046.84	2,100	.97
Pallets (3.52)(17)	59.84	3	19.95	2.39	1.80	24.14	--	8/ 14.96	14.96	39.10	2,100	.02
Bulk-unloading:												
Fork truck	9,097.00	8	1,137.13	363.88	272.91	1,773.92	7/ 136.46	136.46	272.92	2,046.84	2,100	.97
Hopper	9/ 75.00	10	7.50	3.00	2.25	12.75	--	1.13	1.13	13.88	260	.05
Bin carts (40)	9/ 2,000.00	10	200.00	80.00	60.00	340.00	--	30.00	30.00	370.00	520	.71
Belt conveyor	386.50	8	48.31	15.46	11.59	75.36	5.80	5.80	11.60	86.96	520	.17

1/ Straight-line depreciation.
2/ Insurance and taxes at 4 percent of replacement costs.
3/ Interest at 3 percent of replacement cost or 6 percent of the undepreciated balance.
4/ Power at 5 percent of replacement cost for sewing machine and 1.5 percent of replacement cost for conveyor.
5/ Repairs at 1.5 percent of replacement costs.
6/ Based on the assumptions presented in this table and on actual replacement costs.
7/ Power for fork truck at 1.5 percent of replacement cost.
8/ Repairs for pallets at $0.88 per pallet.
9/ Estimated costs.

APPENDIX 3.--APPLICATION OF DATA TO MODEL COMPONENTS

Data applied to components of Model 1

Y_1 = aN + b + c + d + e + f + g + h + i - jN, where:

a = $0.29.
N = 400.
aN = $116.
b = lm + n + op, where:
l = 3.200 man-hours.
m = $3.30.
n = $1.04.
o = 1.600 equipment-hours.
p = $0.12.
b = 3.200 ($3.30) + 1.04 + 1.600 ($0.12).
b = $11.79.
c = qm + rs, where:
q = 2.224 man-hours.
m = $3.30.
r = 2.224 equipment-hours.
s = $0.01.
c = 2.224 ($3.30) + 2.224 ($0.01).
c = $7.36.
d = b'm + c' + tm + uv + wx, where:
b' = 0.500 man-hour.
m = $3.30.
c' = $2.00.
t = 2.221 man-hours.
u = 1.112 equipment-hours.
v = $0.67.
w = 0.333 man-hour.
x = $3.80.
d = 0.500 ($3.30) + $2.00 + 2.221 ($3.30) + 1.112 ($0.67) + 0.333 ($3.80).
d = $12.98.
e = $100.00.
f = $50.00.
g = $510.00.
h = $168.00.
i = yz + l'm' + n'o' + p'q', where:
y = 4.856 man-hours.
z = $1.38.
l' = 0.807 man-hour.
m' = $1.48.
n' = 0.807 equipment-hour.
o' = $0.99.
p' = 0.807 man-hour.
q' = $1.85.
i = 4.856 ($1.38) + 0.807 ($1.48) + 0.807 ($0.99) + 0.807 ($1.85).
i = $10.19.
j = $0.15.
N = 400.
jN = $60.00.

Y_1 = \$116.00 + \$11.79 + \$7.36 + \$12.98 + \$100.00 + \$50.00 + \$510.00 + \$168.00 + \$10.19 - \$60.00.
Y_1 = \$926.32.

Data applied to components of Model 2

Y_2 = a'N + b + c + d + e + f + g + h + i + k + d", where:
a' = \$0.15.
N = 400.
a'N = \$60.00.
b = \$11.79.
c = \$7.36.
d = \$12.98.
e = \$100.00.
f = \$50.00.
g = \$510.00.
h = \$168.00.
i = \$10.19.
k = \$10.00.
d" = h'z + i", where:
h' = 0.755.
z = \$1.38.
i" = \$1.00.
d" = 0.755 (\$1.38) + \$1.00.
d" = \$2.05.
Y_2 = \$60.00 + \$11.79 + \$7.36 + \$12.98 + \$100.00 + \$50.00 + \$510.00 + \$168.00 + \$10.19 + \$10.00 + \$2.05.
Y_2 = \$942.37.

Data applied to components of Model 3

Y_3 = a"N + b + c + d + e + f + g + h + i - j'N, where:
a" = \$0.26.
N = 400.
a"N = \$104.00.
b = \$11.79.
c = \$7.36.
d = \$12.98.
e = \$100.00.
f = \$50.00.
g = \$510.00.
h = \$168.00.
i = \$10.19.
j' = \$0.15.
N = 400.
j'N = \$60.00.
Y_3 = \$104.00 + \$11.79 + \$7.36 + \$12.98 + \$100.00 + \$50.00 + \$510.00 + \$168.00 + \$10.19 - \$60.00.
Y_3 = \$914.32.

Data applied to components of Model 4

Y_4 = d' + e + f + g + h + i'

$d' = e'm + f' + r'm + s't' + u'x$, where:

$e' = 0.667$.
$m = \$3.30$.
$f' = \$20.50$.
$r' = 1.897$.
$m = \$3.30$.
$s' = 1.564$.
$t' = \$0.07$.
$u' = 0.317$.
$x = \$3.80$.

$d' = 0.667\ (\$3.30) + \$20.50 + 1.897\ (\$3.30) + 1.564\ (\$0.07) + 0.317\ (\$3.80)$.

$d' = \$30.29$.
$e = \$100.00$.
$f = \$50.00$.
$g = \$510.00$.
$h = \$168.00$.

$i' = v'z + w'x' + y'q' + z'm' + g'z + d'''$, where:

$v' = 2.917$.
$z = \$1.38$.
$w' = 0.583$.
$x' = \$1.90$.
$y' = 0.583$.
$q' = \$1.85$.
$z' = 0.583$.
$m' = \$1.48$.
$g' = 0.667$.

$d''' = h''z + i''$, where:

$h'' = 0.667$.
$z = \$1.38$.
$i'' = \$1.00$.

$d''' = \$1.92$.

$i' = 2.917\ (\$1.38) + 0.583\ (\$1.90) + 0.583\ (\$1.85) + 0.583\ (\$1.48) + 0.667\ (\$1.38) + 1.92$.

$i' = \$9.95$.

$Y_4 = \$30.29 + \$100.00 + \$50.00 + \$510.00 + \$168.00 + \$9.95$.

$Y_4 = \$869.20$.